Amendments to the Claims

Please amend the claims, without prejudice, as follows, wherein underlining identifies added material and strikethroughs identify deleted material:

Listing of Claims:

1. (Currently Amended) A system for automatically orienting a spherical object using a reference indicium on the spherical object, comprising:

(A) means for automatically locating and defining a position and two-dimensional orientation of the reference indicium; and

(B) means for automatically orienting the spherical object by sequentially rotating the spherical object from the defined position and two-dimensional orientation determined by the automatic locating means through determined ~~predetermined~~ angles so that the reference indicium of the spherical object has a predetermined final position and two-dimensional orientation wherein a target point on the spherical object, which has a predetermined spatial relationship to the reference indicium, is positioned ~~prepositioned~~ for further processing,

wherein the automatic locating and defining means comprises:

(1) first and second locating work stations, each of the first and second locating work stations having a axis of rotation and being operative to rotate the spherical object around the axis of rotation;

(2) transposing means for conveying the spherical object between the first and second locating work stations in such manner that the spherical object is rotated through a single-degree of freedom by 90 degrees between the first and second locating work stations and between the second locating work station and the orienting means, respectively;

(3) an imaging system operative to generate an image of the spherical object at each of the first and second locating work stations as the spherical object is rotated about the axis of rotation of the first and second locating work stations through at least one revolution, respectively; and

(4) calculating means for processing the image of the spherical object generated at the first and second locating work stations, respectively, to locate and identify the

defined position and two-dimensional orientation of the reference indicium and to determine angles for rotation for the spherical object by the orienting means;

wherein the calculating means is operative to process the image of the spherical object generated at the first locating work station to identify a coarse position and two dimension orientation of the reference indicium at the first locating work station and to determine an angle of rotation for the spherical object at the first locating station;

the first locating work station means is operative to rotate the spherical object about the determined angle to move the spherical object to a second position at the first locating work station; and

the transposing means is then operative to convey the spherical object to the second locating work station wherein the spherical object is rotated through the single-degree of freedom by 90 degrees such that the reference indicium is at the defined position and two dimensional orientation on the equator of the spherical object at the second locating work station;

wherein the automatic orienting means comprises:

(1) first, second, and third orienting work stations, each having an axis of rotation and being operative to sequentially rotate the spherical object through one of the determined angles so that the reference indicium is transposed from the defined position and two-dimensional orientation at the first orienting work station to the predetermined final position and two-dimensional orientation at the third orientating work station wherein the target point on the spherical object is positioned for further processing; and

(2) transposing means for conveying the spherical object between the first and second and second and third orienting work stations in such manner that the spherical object is rotated through the single-degree of freedom by 90 degrees between the first and second orienting work stations and between the second and third orienting work stations, respectively;

wherein the transposing means comprises:

(1) a first transposing mechanism pivotally mounted intermediate the first and second orienting work stations and operative to convey the spherical object from the first orienting work station to the second orienting work station in such

manner that the spherical object is rotated through the single-degree of freedom by 90 degrees; and

(2) a second transposing mechanism pivotally mounted intermediate the second and third orienting work stations and operative to convey the spherical object from the second orienting work station to the third orienting work station ~~is~~ in such manner that the spherical object is rotated through the single-degree of freedom by 90 degrees; and

wherein the 90 degrees single-degree of freedom rotation provided by the transposing means between the first and second and the second and third orienting work stations are coplanar with the axes of rotation of the first, second, and third orienting work stations;

the second locating work station is equal to and functions as the first orienting work station; and

the determined angles of rotation implemented by the first, second, and third orienting work stations, respectively, comprise Euler angles of rotation phi, theta plus an additional 90 degrees, and psi, respectively.

2 - 3 (Canceled).

4. (Currently Amended) The system of claim ~~2~~ 1 wherein the 90 degrees single-degree of freedom rotation provided by the transposing means between the first and second locating work stations and the second locating work station and the orienting means is coplanar with the axes of rotation of the first and second locating work stations.

5. (Currently Amended) The system of claim ~~2~~ 1 wherein the imaging system comprises:

a first imaging means having an image axis perpendicular to the spherical object at the first locating work station;

a second imaging means having an image axis perpendicular to the spherical object at the second locating work station; and

wherein the first and second imaging means are operative to generate the image of the spherical object at the first and second locating work stations, respectively.

6. (Currently Amended) The system of claim 1 wherein the imaging system comprises:

a single line sensor camera having an imaging axis ~~imaging means~~;

a first set of mirrors aligned to capture the image of the spherical object at the first locating work station for the single line sensor camera ~~imaging means~~; and

a second set of mirrors aligned to capture the image of the spherical object at the second locating work station for the single line sensor camera ~~imaging means~~;

where the single line sensor camera ~~imaging means~~ is operative, using the first and second set of aligned mirrors, to generate the image of the spherical object at the first and second locating work stations, respectively, and wherein the first and second set of aligned mirrors position the axis of rotation of the first spherical object and the axis of rotation of the second spherical object on the imaging axis of the line sensor camera.

7-9 (Canceled).

10. (Currently Amended) A system for automatically orienting a spherical object using a reference indicium on the spherical object, comprising:

first and second locating work stations each having an axis of rotation and operative to rotate the spherical object about the axis of rotation;

first, second, and third orienting work stations each having an axis of rotation and operative to rotate the spherical object about the axis of rotation through a determined ~~predetermined~~ angle of rotation so that the reference indicium at the third orienting work station has a predetermined final position and two-dimensional orientation wherein a target point on the spherical object, which has a predetermined spatial relationship to the reference indicium, is positioned ~~prepositioned~~ for further processing;

transposing means for conveying the spherical object between the locating work stations and between the orienting work stations in such manner that the spherical object is rotated through a single-degree of freedom by 90 degrees each time the spherical object is conveyed between adjacent work stations, respectively;

an imaging system operative to generate an image of the spherical object at each of the first and second locating work stations as the spherical object is rotated about the axis of rotation of the first and second locating work stations, respectively; and

calculating means for processing the images of the spherical object generated at the first and second locating work stations to locate and identify a defined position and two-dimensional orientation of the reference indicium at the second locating work station and to determine the ~~predetermined~~ angles of rotation for the spherical object at the first, second, and third orienting work stations wherein the reference indicium is rotated from the defined position and two-dimensional orientation at the first orienting work station to the predetermined final position and two-dimensional orientation at the third orienting work station so that the target point is positioned ~~prepositioned~~ for further processing; wherein:

the second locating work station is equal to and functions as the first orienting work station;

the first orienting work station is operative to rotate the spherical object through one of the determined angles of rotation such that the reference indicium of the spherical object is moved from the defined position and two-dimensional orientation at the first orienting work station to a first reference position and two-dimensional orientation at the first orienting work station; and wherein

the transposing means is then operative to convey the spherical object from the first orienting work station to the second orienting work station so that the reference indicium is moved to a second reference position at the second orienting work station; and wherein

the second orienting work station is operative to rotate the spherical object through another of the determined angles of rotation such that the reference indicium of the spherical object is moved from the second reference position and two-dimensional orientation at the second orienting work station to a third reference position and two-dimensional orientation at the second orienting work station; and wherein

the transposing means is then operative to convey the spherical object from the second orienting work station to the third orienting work station so that the reference indicium is moved to a fourth reference position at the third orienting work station; and wherein

the third orienting work station is operative to rotate the spherical object through yet another of the determined angles of rotation such that the reference indicium of the spherical object is moved from the fourth reference position and two-dimensional orientation at the third orienting work station to the predetermined final reference position and two-dimensional

orientation at the third orienting work station such that the target point on the spherical object is positioned for further processing; and.

wherein the one, another, and yet another determined angle of rotation implemented by the first, second, and third orienting work stations, respectively, comprise Euler angles of rotation phi, theta plus an additional 90 degrees, and psi, respectively.

11. (Canceled).

12. (Original) The system of claim 10 wherein the imaging system comprises:

a first imaging means having an image axis perpendicular to the spherical object at the first locating work station;

a second imaging means having an image axis perpendicular to the spherical object at the second locating work station; and

wherein the first and second imaging means are operative to generate the image of the spherical object at the first and second locating work stations, respectively.

13. (Currently Amended) The system of claim 10 wherein the imaging system comprises:

a single ~~imaging means~~ line sensor camera having an imaging axis;

a first set of mirrors aligned to capture the image of the spherical object at the first locating work station for the single line sensor camera ~~imaging means~~;

a second set of mirrors aligned to capture the image of the spherical object at the second locating work station for the single line sensor camera ~~imaging means~~;

wherein the single line sensor camera ~~imaging means~~ is operative, using the first and second set of aligned mirrors, to capture the image of the spherical object at the first and second locating work stations, respectively, and wherein the first and second set of aligned mirrors position the axis of rotation of the first spherical object and the axis of rotation of the second spherical object on the imaging axis of the line sensor camera.

14. (Original) The system of claim 10 wherein the 90 degrees single-degree of freedom rotation provided by the transposing means between the locating work stations and the first,

second, and third orienting work stations is coplanar with the axes of rotation of the first and second locating work stations and the first, second, and third orienting work stations.

15. (Currently Amended) The system of claim 10 ~~11~~ wherein the transposing means comprises:

a first transposing mechanism pivotally mounted intermediate the first and second locating work stations and operative to convey the spherical object from the first locating work station to the second locating work station in such manner that the spherical object is rotated through the single-degree of freedom by 90 degrees; and

a second transposing mechanism pivotally mounted intermediate the first and second orienting work stations and operative to convey the spherical object from the first orienting work station to the second orienting work station in such manner that the spherical object is rotated through the single-degree of freedom by 90 degrees; and

a third transposing mechanism pivotally mounted intermediate the second and third orienting work stations and operative to convey the spherical object from the second orienting work station to the third orienting work station in such manner that the spherical object is rotated through the single-degree of freedom by 90 degrees .

16. (Original) The system of claim 15 wherein the 90 degrees single-degree of freedom rotation provided by the transposing means between the first and second locating work stations, the first and second orienting work stations, and the second and third orienting work stations is coplanar with the axes of rotation of the locating work stations and the orienting work stations.

17 -21. (Canceled)

22. (Currently Amended) The system of claim 10 wherein

the calculating means is operative to process the image of the spherical object generated at the first locating work station to identify a coarse position and two-dimensional orientation of the reference indicium at the first locating work station and to determine an angle of rotation for the spherical object at the first locating work station; and wherein

the first locating work station is operative to rotate the spherical object through the determined ~~predetermined~~ angle wherein the reference indicium is moved from the defined coarse position and two-dimensional orientation to a second defined position and two-dimensional orientation at the first locating work station; and wherein

the transposing means is operative to convey the spherical object from the first locating work station to the second locating work station wherein the spherical object is rotated through a single-degree of freedom by 90 degrees such that the reference indicium of the spherical object is located at the defined position and two-dimensional orientation at the second locating work station.

23 - 24 (Canceled).

25. (Currently Amended) A method of automatically orienting a spherical object using a reference indicium on the spherical object so that a target point, which has a predetermined spatial relationship with the reference indicium, is positioned ~~prepositioned~~ for further processing, comprising ~~the steps of~~:

locating and defining a position and two-dimensional orientation of the reference indicium on the spherical object;

calculating, based on the defined position and two-dimensional orientation of the reference indicium, ~~predetermined~~ angles of rotation for the spherical object to move the reference indicium from the defined position and two-dimensional orientation to the predetermined final position and two-dimensional orientation;

rotating the spherical object at a first orienting work station through one of the calculated ~~predetermined~~ angles of rotation to move the reference indicium from the predefined position and two-dimensional orientation to a first reference position and orientation at the first orienting work station;

conveying the spherical object from the first orienting work station to a second orienting work station in a manner such that the spherical object is rotated through a single-degree of freedom by 90 degrees wherein the reference indicium is at a second reference position and two-dimensional orientation at the second orienting work station;

rotating the spherical object at the second orienting work station through another of the calculated ~~predetermined~~ angles of rotation to move the reference indicium from the second reference position and two-dimensional orientation to a third reference position and two-dimensional orientation at the second orienting work station;

conveying the spherical object from the second orienting work station to a third orienting work station in a manner such that the spherical object is rotated through a single degree of freedom by 90 degrees wherein the reference indicium is at a fourth reference position and two-dimensional orientation at the third orienting work station; and

rotating the spherical object at the third orienting work station through yet another of the calculated ~~predetermined~~ angles of rotation to move the reference indicium from the fourth reference position and two-dimensional orientation to the predetermined final position and two-dimensional orientation at the third orienting work station wherein the target point is positioned ~~prepositioned~~ for further processing;

wherein the one, another, and yet another calculated angles of rotation, respectively, comprise Euler angles of rotation phi, theta plus an additional 90 degrees, and psi, respectively

26. (Currently Amended) The method of claim 25 wherein the step of locating the defined position and two-dimensional orientation of the reference indicium on the spherical object comprises ~~the steps of~~:

providing the spherical object having a random position and two-dimensional orientation of the reference indicium at a first locating work station;

imaging the spherical object at the first locating work station;

determining a coarse position and two-dimensional orientation of the reference indicium using the generated image;

calculating an angle of rotation for the spherical object at the first locating work station using the generated image;

rotating the spherical object through the calculated angle of rotation to move the reference indicium from the coarse position and two-dimensional orientation to a second position and two-dimensional orientation at the first locating work station;

conveying the spherical object from the first locating work station to a second locating work station in a manner such that the spherical object is rotated through a single-degree of

freedom by 90 degrees wherein the reference indicium is at the defined position and orientation at the second locating work station;

imaging the spherical object at the second locating work station; and

locating and defining the defined position and two-dimensional orientation of the reference indicium of the spherical object at the second locating work station using the generated image.

27. (Currently Amended) A system for imaging the surface of a spherical object, comprising:

a first work station having an axis of rotation and operative to rotate the spherical object about the axis of rotation, and wherein a plane of the spherical object perpendicular to the axis of rotation is defined as the rotational plane of the spherical object at the first work station;

a second work station having an axis of rotation and operative to rotate the spherical object about the axis of rotation, and wherein a plane of the spherical object perpendicular to the axis of rotation is defined as the rotational plane of the spherical object at the second work station;

transposing means for conveying the spherical object from the first work station to the second work station in such manner that the spherical object is rotated through a single degree of freedom by 90 degrees wherein the rotational plane of the spherical object at the first work ~~working~~ station is rotated through an angle of 90 degrees such that the rotational plane defined by the spherical object at the first work station is perpendicular to the rotational plane of the spherical object at the second work station; and

an imaging system positioned and operative to generate an image of the surface of the spherical object at each of the first and second work stations; and wherein

the imaging system is operative to generate a first image of the surface of the spherical object as the spherical object is rotated through at least one complete revolution about the axis of rotation of the first work station; and wherein

the imaging system is operative to generate a second image of the surface of the spherical object as the spherical object is rotated through at least one complete revolution about the axis of rotation of the second work station; and

the first and second work stations are substantially identical in structure.

28. (Original) The system of claim 27 wherein the imaging system comprises:

a first imaging means having an image axis perpendicular to the spherical object at the first work station and operative to generate the first image of the surface of the spherical object; and

a second imaging means having an image axis perpendicular to the spherical object at the second work station and operative to generate the second image of the surface of the spherical object.

29 - 33 (Canceled).